SOIL SURVEY OF THE DUBUQUE AREA, IOWA.

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LOCATION AND BOUNDARIES OF THE AREA.

The Dubuque area includes 440 square miles, or 281,664 acres, and is situated in east central Iowa, the Mississippi River flowing through the northeast corner. A small part of it lies across the river, in the State of Illinois. To give its boundaries more exactly, it is a 15 by 30 minute sheet extending from longitude 90° 30′ to 91° west from Greenwich and from latitude 42° 15′ to 42° 30′ north. Parts of

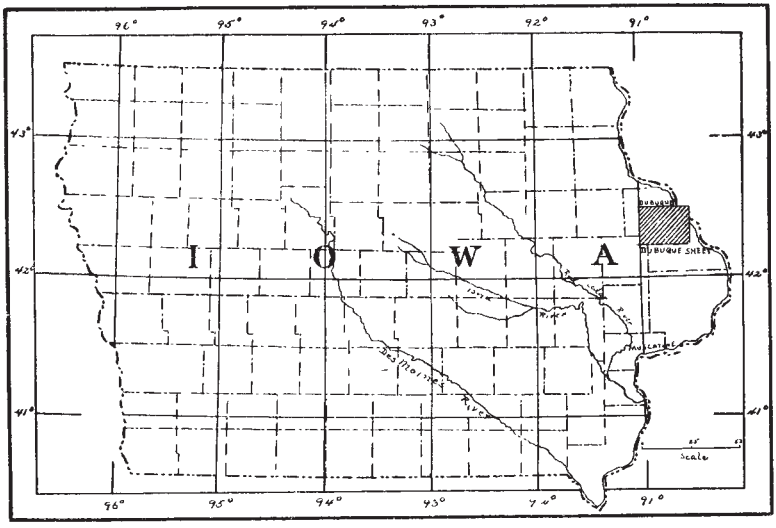

FIG. 15.—Sketch map showing area surveyed in Iowa.

Dubuque, Jackson, and Jones counties, Iowa, and Jo Daviess County, Ill., are included in the area. The largest city is Dubuque, situated on the Mississippi River, and the other important towns are Farley and Cascade, in the western part of the sheet. A half dozen villages are scattered through the area at convenient centers for local trade, and a number of smaller hamlets and crossroad post-offices lie within the area. (See fig. 15.)

The center of trade is Dubuque, a city of nearly 40,000 inhabitants, which, besides being an important railroad center between the East and the Northwest, has in the Mississippi River excellent water communication with many large cities both North and South.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The earliest commercial interest of the area surveyed lay in mining the deposits of lead that occur in the prevalent Galena limestone formation. Julien Dubuque, after whom was named the city of Dubuque, founded in 1825, was the first to mine the deposits in a commercial way. His operations covered the period from 1780 to 1810. Permanent mining operations were begun, about the time of the founding of Dubuque, by pioneers coming from Galena, Ill. As late as 1852 the Upper Mississippi mines yielded 10 per cent of the world's supply of lead and 78 per cent of the production of the United States.

The chance of quickly winning wealth by a rich strike in lead distracted interest from agricultural pursuits, and hence during the twenty years following settlement the development of agriculture in the vicinity of Dubuque was slow.

In its original condition part of the area surveyed was timbered and part was covered by only a scattered growth of hazel bush and other kinds of shrubs. The more broken lands along the Mississippi River, together with fringes along the streams, were occupied by forests of white, black, and bur oak. Maple, basswood, hickory, elm, and poplar also occurred. As the timber growth was largely oak, the term "oak openings" was applied to large areas. In the area above or west of the Niagara escarpment, comprising the rolling prairies, there was no timber, except here and there an occasional tree and a narrow fringe of trees along the streams. Here grew coarse prairie grasses, while large hazel brush extended for a considerable distance out from the timber, as its forerunner. Why there should have been such vast areas without timber covering is a question still awaiting a satisfactory explanation. There is apparently no difference in the soils sufficient to account for such a difference of vegetation. One cause sometimes suggested as possible is the prairie fire, and this theory has much to commend it to further careful consideration.

The first agricultural settlement began in 1830 on the prairie lands, which were easily cleared and quickly brought under the plow. By 1850 practically all such land had been reclaimed, and the timbered lands were being rapidly taken up. The open character of much of the forest made the clearing comparatively easy. The hilly lands along the Mississippi River are said to have been the last to be brought under cultivation. Within the last forty years the local demand for produce has led to the careful tillage of every available slope in the vicinity of Dubuque.

The freshly turned prairie and the newly cleared slopes were very fertile, and all crops yielded in abundance. At that time the leading crop was spring wheat, the yields ranging from 20 to 35 or 40 bushels

per acre. Corn and hay were grown, but only in limited amounts for local consumption. Live stock, outside of draft animals, were few, and hence the demand for forage was small.

There are several reasons why wheat was the leading crop in those days. The fertile soil yielded generously, the grain formed the principal bread crop, it stood shipment well by water—the Mississippi River being the one connection with the large cities of the East and with foreign ports—and prices were good. Had corn been produced it would have had a more limited outside market, while as feed for live stock the demand would have been light, live stock being raised only for local consumption.

Wheat continued to be the principal crop until about 1875, when it began to give place more and more to corn and hay, which were fed to live stock. From that time to the present the chief products of the farms of the area, in common with eastern Iowa generally, have been cattle and hogs, with a few sheep. There is more than one reason for the transition. The continual growing of wheat on the same land was reducing its fertility, and hence the yield, and the advent of railroads—the present Illinois Central line in 1867 and the Chicago and Northwestern a few years later—opened the way to the shipment of live stock and corn to the East. Added to these forces, and probably stronger than they at the time, were the serious ravages of the chinch bug, which for several years in succession not only destroyed whole fields of wheat, but entered the corn fields after the wheat harvest and did much damage to that crop. When wheat growing had once been discarded for forage crops, live-stock raising and dairying were inaugurated, and the substitution was found to be so much more satisfactory that it continued without interruption, and for the decade from 1890 to 1900 the average yearly production of wheat was comparatively insignificant. Within the last two or three years small trials of wheat have been made with such success that the production of spring wheat bids fair to again assume a prominent place in the crop rotation.

Barley is another crop that formerly received much more attention than at present. Twenty years ago a large acreage was planted, producing from 25 to 35 bushels per acre, and there was a strong demand at good prices. The demand seems to have been curtailed and the acreage has greatly decreased, barley being grown now mainly for feed.

In the live-stock industry the tendency has been from beef production to dairying, the butter being manufactured in factories. This change has come within the last fifteen years. The general features of the country, its surface configuration, and the character of the soil make the production of live stock and dairying most practicable and profitable. The hilly character of the surface in many parts, the

stony slopes, and the serious damage that may arise from erosion when such areas are kept in cultivated crops are conducive to a large acreage of grass and pasture land, and hence no radical changes in the general system of agriculture of the area are likely to take place. This last statement is not to be understood as excluding modifications in the methods of agricultural practice, which will be considered later in this report.

CLIMATE.

The mean annual temperature for the Dubuque area is about 46° F. and the mean annual precipitation is between 30 and 36 inches.

The following table gives the figures of normal temperature and precipitation at two of the Weather Bureau stations, Dubuque and Delaware, in detail by months:

Normal monthly and annual temperature and precipitation.

Month	Temperature.		Precipitation.	
	Dubuque	Delaware.	Dubuque	Delaware.
	°F.	°F.	*Inches*	*Inches.*
January	17.7	14.3	1.68	1.22
February	22.6	18.1	1.46	.78
March	32 8	30 9	2.27	1.81
April	48 6	46.7	2.79	3.38
May	59.9	57.9	3.99	3.82
June	69 1	68.7	5 20	4 28
July	74.2	71.6	4.28	3.30
August	72 0	68 8	3 15	2.88
September	63.0	61.8	4.09	3.36
October	50 9	46 5	2.71	2.28
November	35 0	29.5	2.10	1.76
December	25.1	21.1	1 81	1.52
Year	47.6	44.6	35.53	30.39

The annual precipitation is thus about 33 inches, and of this amount nearly five-eighths fall during the growing season, which is a very satisfactory arrangement of the distribution. However, periods of more or less severe drought occur from year to year.

Since the beginning of settlement there have been changes in the water supply of the area so marked that they have come under the observation of every old settler. The region was once famous for the number and large size of its springs of water and perpetually flowing brooks, but at the present time very few springs are to be found, the flow of the largest ones is very much reduced, and the majority of the small streams are without water during a large part of the year.

The records kept at Delaware show killing frost in the spring as late as May 31, but the average date, taking the records of the last

eight years as a basis, is May 2. The earliest frost in fall of sufficient severity to kill tender vegetation occurs usually about October 2. There are, thus, one hundred and fifty-three days in the growing season around Delaware. Near Dubuque the average length of the growing season is one hundred and sixty-seven days, extending from the average killing-frost date of spring, April 19, to that of fall, October 3. The figures given for these two stations may be taken as indicating average conditions in the area at large.

PHYSIOGRAPHY AND GEOLOGY.

The surface of the Dubuque area is generally rolling and hilly. Along the Mississippi River, which flows across the northeastern corner, separating the Iowa part of the area from that in Illinois, the topography is rougher and still more broken. The elevation ranges from 600 feet along the river to 1,200 feet on the divide, some 10 miles to the west. This divide, which is in fact a watershed between the two sets of streams that drain the area, extends from Farley to Epworth and thence in a southeast line through Lamotte. Throughout its whole extent it maintains an elevation of not less than 1,000 feet, and for the greater part of the distance reaches 1,100 feet. An elevation of 1,200 feet is reached in three small knolls in the southeastern corner of Table Mound Township. The entire drainage finds its way into the Mississippi River. The streams east of the divide are short and flow directly into the Mississippi, while those on the west reach it indirectly through the Maquoketa River and its tributary, the North Fork, which cuts across the southwest corner of the area at Cascade. The streams west of the divide are much longer and generally have a less slope.

The area was originally a plateau composed of limestone and shale, but out of the once level surface the streams have carved a complete system of channels of the dendric type. The streams divide and subdivide until they end in a thousand small brooks and rills that find their source for the most part in the headlands bordering the main divide or watershed. As a result of the work of the many streams the whole country is now a series of rounded ridges with a long swell, as in the region of shale, or with precipitous slope where limestone is the basal material. The general convex outline of the ridges and valleys shows that the process of eroding the country down to base level is scarcely half completed, notwithstanding that hundreds of feet of material have been carried away.

The physiography of the area may be described under two general heads—the driftless area, occupying the eastern third of the area surveyed, and the area of glacial debris lying above or west of the main

divide. The former of these includes the Mississippi River and those streams that flow directly into it, and affords an excellent example of the kind of surface this whole northern country would now present had there been no ice invasion to plane down the eminences and fill in the depressions. It is characterized by bold outlines and rugged cliffs. The two series of limestones and the intervening stratum of shale have been cut through, the streams occupying narrow, rock-bound gorges where they pass through the limestone and comparatively deep channels where they pass through shale. The gorge of the Mississippi River, extending in a southeast direction, has an average width of 1½ miles and is bounded on each side by rocky walls, ranging in height from 250 feet at Gate City, where they approach nearest each other, to 60 feet at other points along the course. Where inflowing side streams have cut through them these walls follow the course of the streams, forming precipitous slopes simulating canyons. The varying hardness of the rock has caused it to be eroded unevenly, and the more obdurate parts have been chiseled into giant columns that form, with their rugged outline and their honeycombed and weather-beaten surfaces universally set in a mass of vegetation, a striking part of the scenery of the country. Instances of this kind abound in all the region around Dubuque, and in passing up or down the stream courses one pleasing vista succeeds another in rapid succession. The formation occurs alike in the upper and lower limestone regions, only differing in the extent to which erosion has progressed. The softer parts of the limestone form more gentle and receding slopes, while the shale gives very long, rounded slopes with a graceful swell.

The bottoms of the gorges are occupied by a ribbon of flat, level land, through which the streams wind in narrow channels, usually with almost vertical walls. The larger streams have a more meandering character and the materials composing these bottoms are less uniform. The main stream of the Mississippi River flows through flat bottom lands, through which bayous and side channels have cut their way, forming a number of islands of varying sizes. These islands are low, flat, and subject to occasional overflow. Near Dubuque considerable island areas are cultivated, but below the city they are covered with timber. The other large streams of this part of the area are Catfish Creek and its tributaries, the Tête de Mort River, and the headwaters of the Little Maquoketa, the valleys of all which have the character of those of the small streams in general. The channels are seldom divided, and overflows of the bottom lands occur only at long intervals.

Aside from the lower stream gorges, a distinct phase of the topography of this region is the outcropping edge of the magnesia limestone, whose proper place in the geological scale will be noted later in this report. This outcrop, known as the Niagara escarpment,

extends over the country as a sinuous line of hills with steep slopes ranging in height from 60 to 150 feet. On the large inner stream divides it extends far out toward the Mississippi River, while along the streams it recedes, forming a steep rim to the valleys and finally embracing their sources. The sudden rise of these limestone hills from the long slope of the shale is most noticeable. Table Mound, in Table Mound Township, as well as numerous other hills that are less marked, are the extensions of this Niagara limestone formation. The Niagara escarpment is between 6 and 10 miles from the river at Dubuque and approaches to within half a mile of the river on the east central border of the area. On the eastern side of the Mississippi River this escarpment does not occur in the area, the Niagara limestone formation being absent. The other topographic features are identical with those on the Illinois side of the river.

The western two-thirds of the area is more level than the eastern part and is sometimes spoken of as the rolling prairie. It is far from being level, but the slopes are more gentle and of a less height. The general slope is to the southwest. The larger streams are John, Whitewater, Prairie, and other creeks, besides a part of the North Fork Maquoketa River. These streams belong to the dendric or ramifying type, but have cut less deep into the limestone, and besides, the area has been overrun by ice, which tended to plane down the ridges and fill in the depressions. The most broken area is along the North Fork Maquoketa in the region south of Washington Mills. In the western 6-mile tier of sections there are three distinct lobes which have been twice overrun by the glaciers. Here the outlines are distinctly more modified than in the other portions of this western area. The hills present the appearance of having been rubbed or plowed down, and there are no sharp slopes. The lobes have a southwest direction, entering the area at Farley, in northern Whitewater Township, and at Cascade. The stream gorges and the bottom lands are of the same character as those in the eastern third of the area.

From a geological point of view the area under consideration is one of the most interesting in the country, because of the variety of its materials, the character of their exposures, and the topography resulting from their relative positions. The lowest formation exposed to view in the area is the Galena limestone, which forms the bluffs fringing the Mississippi River and its tributaries. It is 250 feet thick at Dubuque. It is a buff or gray-colored stone, strongly magnesian, somewhat cherty, and the source of the lead mined at Dubuque. Above the Galena formation occur the Maquoketa shales. They are blue or drab in color and very heavy and impervious. To their easy weathering is due the long, rounded slopes between the lower and

upper limestones which are so noticeable in the vicinity of Dubuque. When weathered out the shale forms a most intractable blue clay, so stiff that it would seem impossible to utilize it for agricultural purposes were it on the surface.

The third formation is the Niagara limestone. It is a creamy to gray colored stone, very cherty and highly dolomitic. Its thickness varies from 30 to 350 feet and its exposure ranges from an elevation of 800 to 1,200 feet above tide.

The residual material from both the limestone formations is a very stiff, sticky, dark red clay filled with chert fragments. The color is due to the high percentage of iron compounds which the rock contains. It nowhere forms a considerable portion of the surface covering.

In general, the area over which the Niagara limestone is the highest indurated formation has been subjected to glacial action. Two distinct advances of the ice are discernible, between the occurrence of which countless centuries elapsed. The first of these was the Kansian glacier, which spread over the country as far as the Niagara escarpment. The border of this ice sheet waves back and forth over several miles of territory, a distinct morainic deposit occurring throughout much of its extent. The materials composing the drift are sands, clays, and bowlders in varying proportions.

Of the strata that have been mentioned thus far none enter into the formation of the present soil covering of the area. The limestones might seem to be exceptions to this, but they are represented only by stony outcrops, the fine material mixed with these rock fragments being of another origin. Only glimpses of the other formations are had occasionally in gullies and cuts.

The second or Iowa invasion of the ice was the source of the present soils. The drift from this glacier is only found in the western fourth of the area, where it occurs as the elongated lobes of small hills, the first entering at Farley and reaching to Epworth, the second entering in northern Whitewater Township and reaching to Bernard, and the third following the North Fork of Maquoketa River and one of its tributaries from Cascade to a point a few miles south of Garry Owen. All three have a southeast direction. They are mainly indicated by a series of sandy loams, with occasional large and small erratic bowlders scattered about on the surface. Reaching out from the border of the Iowa drift is a continuous sheet of finely divided and homogeneous material lying unconformably over the formations mentioned. It is largely a silt, and contains no particles coarser than fine sand. Because of certain peculiarities it has been termed loess, and is correlated with vast areas of the same material that extend through the Mississippi Valley from southern Louisiana and Mississippi to Canada. This is the material from which 90 per cent of the soils of the area is derived.

The geological formations that are exposed and their position in the scale and the soils derived from them are given in the following table:

Time.	Era.	Period.	Formation.	Soil.
Cenozoic	Pleistocene or Quaternary	Recent	Alluvium	Meadow.
				Lintonia loam.
		Glacial	Wisconsin terraces	Miami fine sand.
			Iowa drift	Miami sandy loam.
			Loess	Miami silt loam.
			Buchanan gravels	No representation.
			Kansas drift	
Paleozoic	Silurian	Niagara	Residual products	
			Delaware	Clarksville stony loam.
	Ordovician	Trenton	Maquoketa	No representation.
			Galena	Clarksville stony loam.

In the Dubuque area the loess is spread over the surface as a veneer that covers hill and valley with unfailing uniformity. It extends from the Mississippi River bluffs to the border of the Iowa drift, and reaches many miles to the southwest of the area. The general elevation in the western portion is much greater than in the east, but there seems to be no difference in the characteristics of the material in different parts of the area. While the thickness of the loess mantle is not uniform, it maintains a general consistency in that the greatest depths occur along the Mississippi River and near the drift margin. It is also thickest on the crowns of the hills and divides, attenuating over the brows and down the slopes. Around Dubuque the mine shafts cut through from 10 to 30 feet of this material, and in all parts of the area the exposed sections are from 2 to 20 feet in depth. It is difficult to state an average figure for the depth of the material over the whole area, but from 6 to 10 feet would not be far amiss.

Typical loess is neither a sand nor a clay, but a yellow silt of intermediate fineness, that consists of certain definite proportions of silica, carbonate of lime, iron, aluminum, etc., and contains nodules of lime and iron (called loess kindchens), ramifying calcareous tubes, and shells of land and fresh-water mollusks. It is homogeneous and free from pebbles and other adventitious material, and is generally rich in lime carbonate, so that it effervesces freely with acid. The carbonate may occasionally be highly magnesian, but it is not to be regarded as derived from the included shells. While the loess is soft and easily cut with a spade or molded in the hand when moist, it resists erosion to a remarkable degree, forming vertical faces which remain intact for long periods of time. Toward the base it generally exhibits a tendency to split along vertical planes, and careful examination exhibits traces of stratification, as shown by series of thin plates that with care may be separated. The uniformity of the particles and the general lack of clay

impart to the material a friable, open structure that absorbs and holds water much as a sponge does.

The loess of the Dubuque area differs from the typical material in being richer in clay and poorer in the various lime and magnesian carbonates; also in containing a smaller number of nodules and shells. The clay content is greatest in the upper portion of the material, extending from 2 to 6 feet below the surface. The thickness of the clayey band is greatest along the Mississippi River on each side, becoming thinner and less apparent toward the drift border. Here its thickness is usually about 3 feet. The presence of the clay is shown both by the appearance of the material in mass and by the peculiar joint-plane structure which enables it when dry to form small angular clods from the size of wheat grains, or smaller, to that of grains of corn. Along these joint planes it is common to find a thin layer of white powdery material consisting of very fine sand. This may be seen in breaking apart masses of the moist silt.

Determinations of the chemical and mineralogical composition of the loess of different parts of the Mississippi Valley show a variety of minerals, depending upon the kind of rocks from which the soil is derived, as well as variations in the amounts of the different elements. Although these differences occur, as between the loess from Iowa, Illinois, Missouri, and Mississippi, within narrow limits, the composition is quite uniform. From the chapter on loess in the Sixth Annual Report of the U. S. Geological Survey we copy the following chemical analysis of a sample of loess taken a few miles west of Dubuque:

Silica (SiO_2)	76.68
Alumina (Al_2O_3)	12.03
Ferric oxide (Fe_2O_3)	3.53
Ferrous oxide (FeO)	.96
Titanic acid (TiO_2)	.72
Phosphoric acid (P_2O_5)	.23
Manganese oxide (MnO)	.06
Lime (CaO)	1.59
Magnesia (MgO)	1.11
Soda (Na_2O)	1.68
Potash (K_2O)	2.13
Water (H_2O)	2.50
Carbonic acid (CO_2)	.39
Sulphuric acid (SO_3)	.51
Chlorine (Cl)	.09

The minerals that constitute the loess are a large proportion of quartz and feldspar and lesser amounts of orthoclase, plagioclase, biotite, muscovite, hornblende, calcite, dolomite, and some others.

While the origin of this vast sheet of silt is shrouded in mystery, because of the seeming conflict of facts, it is generally conceded that in eastern Iowa the loess was derived from the Iowa glacier. By some

agency the finer material was carried far beyond the ice margin and deposited over the then existing surface as a comparatively thin sheet. The glacial origin is indicated by the contemporaneous occurrence of the glacial drift and the loess and by the peculiar relative position of their borders, the eastern margin of the drift being the western margin of the loess.

In China the loess seems undoubtedly to have been laid down by æolian action, says Von Reichtofen, but in the Mississippi Valley this force alone would not meet all the facts, and hence from the study of Shimek, Udden, Wilder, and many others, the agency of water is added to that of the air to account for the unique distribution, the homogeneous texture, and the obscurely stratified structure of the material. The most consistent view of its origin seems to be a wind-blown dust drifted in deep, quiet water. The often platy structure, in connection with the massive appearance, upholds this idea. Even this theory leaves some points unsettled, and the problem is still open to definite solution.

SOILS.

The soils of the Dubuque area have been divided into six types, including Meadow. The area of each of these, with the percentage of the total area, is given in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Miami silt loam	176,896	62.8	Meadow	4,160	1.5
Clarksville stony loam	60,672	21.6	Miami fine sand	2,624	.9
Lintonia loam	22,272	7.9			
Miami sandy loam	15,040	5.3	Total	281,664	

The types which have been recognized are all well defined, and the boundaries of each are sharply marked.

MIAMI SILT LOAM.

In the Dubuque area the Miami silt loam is by far the most prominent type, as is indicated by its occupying 62.8 per cent of the whole area, extending from one boundary to the other in an almost unbroken body. It is the type which determines the agricultural interests of the country and the one preeminent in the production of all the crops that find a place in the farming of the region.

The surface is rolling and hilly and made up of a system of divides, developed by the erosion of the streams, and the soil disappears only where the slope is so steep that it has been carried away by the downward rush of the surface water. The roughest areas are below the

Niagara escarpment on each side of the Mississippi River, where the soil covers the long, rounded slopes overlying the Maquoketa shales. While making cultivation somewhat difficult, these slopes are seldom so steep as to be untillable, and the whole area is farmed. No extensive level stretches of the type occur in this part of the area, because the shorter streams have channels proportionally deep for the width of the divide. West of the Niagara escarpment and the main divide of the county, where the streams are longer and have a less fall, the divides are broader and the country correspondingly more level. Perfect natural drainage is established on this type throughout the area.

The soil is derived from the weathering of the loess and is practically coextensive with that material. As is indicated by its name the Miami silt loam is composed largely of silt. The surface 12 inches, which is the average depth of the soil, is a friable dark-brown or yellow silt loam, free from gravel or rock fragments. The soil in the region of the steepest slopes has been subject to continual heavy erosion, rendering it thin, somewhat clayey, and less rich in organic remains. In these places it ranges from 7 to 10 inches in depth, and has a light grayish-yellow or reddish-brown color that is particularly noticeable over the brows of the hills, where the most severe erosion occurs. Here the soil is also more clayey in texture. Within the area of the rolling prairie, where the washing and erosion have been less severe, the depth of the soil ranges from 12 to 18 inches, and the color becomes darker because of the accumulation of organic matter. Its greatest extent is along the main divide, where it forms a triangle, with Peosta, Lamotte, and Cascade as the points.

The subsoil of this type is subject to less variation than the soil, consisting of a yellow clayey silt to a depth of 3 feet or more. The clayey stratum has a depth of 2 to 6 feet. This character of the soil is more marked near the Mississippi River than elsewhere. Below the clayey stratum occurs the almost pure silt of the loess, which rests in turn upon the various basal materials of the area, consisting of the residual clay, shales, limestones, and glacial debris.

A noticeable peculiarity of the subsoil is its tendency when dry to form innumerable joint planes that cut the material into small angular clods. Along each of these planes there is found a very fine white sand. Even where the masses of the moist material are broken apart this characteristic cleavage is apparent, and the small eroded gullies show a bottom composed of this flaky mass.

This type of soil in the region of greatest erosion and brightest color is locally called "clay," while the prairie phase is termed "dark loam." It would seem that the term "clay" is almost justified in some parts of the area, as, for instance, in the vicinity of Dubuque and in Menominee Township. There are local areas, notably along the North Fork Maquoketa, where the soil has a grayish-white color when the culti-

vated land is dried after a rain. In crop value such soil is said not to differ materially from the darker colored soil in the same locality. Extending from near Fillmore eastward to beyond Bernard is an area of 5 or 6 square miles where there is considerable sand mixed with the silt. This is the result of the mingling of the glacial sands with the silt along the border of the drift. Here the slopes are very long and gentle in every part. The soil is a dark silt loam to a depth of 18 inches, containing small amounts of sand. The subsoil to a depth of 36 inches is a clayey sand or in some parts a very sandy clay of a yellow color. Glacial pebbles and bowlders are scattered through the soil and upon the surface.

A similar phase of the Miami silt loam occurs about 2 miles south of Epworth. The crops and yields are the same as those of the surrounding soil.

The texture, structure, and depth of the Miami silt loam combine to give it a most satisfactory relation to moisture. The fine silt particles and the presence of only a small percentage of clay particles enable it to readily absorb a large amount of water and to retain it for long periods, while any excess of water finds its way through the material to the underlying formations. As these are always more or less tilted the drainage is thorough and tiles are unnecessary. The Niagara limestone underlies a large part of this type, and frequently it contains large crevices, particularly near the margins, into which the surface water disappears and is drained away. These sink holes are from 1 to 3 rods in diameter, sometimes occurring in series. Curiously enough, very few of these were noted in the regions of the Galena limestone, probably because the overlying shales are too obdurate.

The friable character of the soil, its wealth of lime compounds, and its general fertility adapt it to the production of grains and grasses. There is no obstruction, save the surface features, to the turning of every foot of it with the plow, at least fair crops being always assured. Its cultivation is free from many of the inconveniences of heavier and lighter soils. No soil can absorb larger amounts of water or withstand more protracted drought with as little evil effect on the crops as can the type under consideration. There are no troublesome clods to vex the farmer, and a suitable seed bed may be obtained with the minimum amount of labor. A tendency toward "heaving" of winter crops by alternate freezing and thawing is one of the worst features of the soil. It also washes badly on the steeper slopes, and against this the farmer must continually guard. A common practice is to leave the hillside draws in grass, the fibrous roots holding the soil in place. Where great gullies have been formed their extension has been checked by brush dams that permit the passage of the water, but so lessen its current that its burden of silt is dropped.

With the present system of farming the leading crop grown is corn, the yield of which ranges from 25 to 80 bushels per acre, with a probable average of about 45 bushels. To this crop is added a considerable acreage of oats, rye, and grass, the last consisting of timothy and some clover for hay and blue grass for pasture. Barley is occasionally grown. Wheat was formerly produced in considerable quantities and its cultivation is being revived, as has been previously noted. On the more level areas the average production per acre for these crops may be placed at 40 bushels for oats, 20 bushels for rye, 30 to 35 bushels for barley, 18 bushels for wheat, and 1½ tons for hay. For the more broken areas these figures are somewhat above the average. This soil is well adapted to the production of these crops, and with the present system of farming there are a number of forage and other crops that might be added to the list with good results. Among these may be mentioned alfalfa, rape, Kafir corn, and sorghum. Alfalfa deserves especial attention in view of the recent failure of clover.

To the grain and grass crops may be added a number of the small fruits and some tree fruits of the hardier varieties, such as apples, plums, and pears. This soil type will undoubtedly produce these fruits in profusion if moderate care is exercised in the management of them.

The following table gives mechanical analyses of this soil type:

Mechanical analyses of Miami silt loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6708	2 miles S. of Zwingle.	Dark silt loam, 0 to 12 inches.	2.50	0.06	0.54	0.36	1.34	14.76	70.52	11.32
6704	2¼ miles S. of Menominee.	Grayish-brown silt loam, 0 to 10 inches.	.65	Tr.	.48	.38	1.46	21.28	64.70	11.48
6706	4½ miles SW. of Dubuque.	Grayish-brown silt, 0 to 10 inches.	2.31	.00	.56	.38	1.26	15.66	69.90	11.72
6710	1 mile E. of Bernard.	Dark sandy silt loam, 0 to 18 inches.	1.68	.56	3.40	5.04	9.06	13.90	49.16	17.94
6702	Cen. W. border sec. 22, Vernon Tp.	Brown silt loam, 0 to 15 inches.	2.67	.28	.50	.30	.60	5.44	72.02	19.18
6707	Subsoil of 6706.....	Yellow silty clay, 10 to 36 inches.	.51	Tr.	.22	.36	.72	15.46	72.14	10.86
6705	Subsoil of 6704.....	Yellow clayey silt, 10 to 36 inches.	.42	.00	.62	.28	.98	22.22	64.26	11.66
6709	Subsoil of 6708.....	Yellow clayey silt, 12 to 36 inches.	.47	.04	.66	.30	.72	13.14	72.14	13.30
6703	Subsoil of 6702.....	Yellow clayey silt, 15 to 36 inches.	.84	.00	.30	.22	.30	14.72	70.02	13.36
6711	Subsoil of 6710.....	Yellow sandy clay, 18 to 36 inches.	.45	2.24	6.14	5.88	14.16	13.56	31.38	25.48

CLARKSVILLE STONY LOAM.

Outcrops of the two limestones occur along the rivers and smaller streams in every part of the area, forming steep and often precipitous slopes strewn with rock fragments and cut by projecting ledges of the massive rock. The formations are the Galena and the Niagara limestones, the former giving rise to the bluffs along the Mississippi River and the lower courses of its tributaries, and the latter forming the upper series of steep slopes from which are derived the valley rims and many spurs, such as Table Mound. These outcrops are most numerous and extensive in the eastern part of the area, in the broad gorge of the Mississippi, and in the western part adjacent to the larger streams. They form but a small percentage of the area, as compared with the Miami silt loam, but because of their rough and rugged features they exercise a profound influence on the agricultural value of that and other soils in connection with which they occur.

The Clarksville stony loam owes its derivation and its characteristics to these limestone outcrops. The soil is a rich black silt loam, from 8 to 15 inches in depth, containing from 30 to 60 per cent of limestone and chert fragments. In addition to the silt, which is derived from the washings of the loess, the soil contains more or less residual material, consisting of clay and sand, which imparts something of a sandy loam character to some of the areas.

The subsoil, like the soil, is silty and often quite clayey, due to the greater quantity of residual material incorporated with the loess, while the quantity of rock fragments is increased, ranging from 40 to 70 per cent of the entire mass. Very often bed rock occurs within 2 or 3 feet of the surface. The limestone fragments are of all sizes, from blocks weighing tons to small pebbles, and their shape is quite as variable. They have a cavernous or honeycombed surface, due to the weathering out of the softer portions. As the Niagara limestone contains much the larger amount of chert, it follows that the stony loam of the higher elevations contains a greater abundance of that material, and the surface of some of the areas of the type is practically a mass of these fragments.

The dark color of the soil is due to the high percentage of included organic matter. The subsoil from which this has been excluded is generally a dull-yellowish color. Over the rocky cliffs there is, of course, no soil covering, and in other places only a few inches of silty material rests upon the heavy, intractable residual clay. The extent of both of these phases is small. The type includes the brows of the hills and the lower talus slopes. Since the surface inclination is at such a high angle it happens that the areas are somewhat exaggerated on the accompanying map, where topographic lines have been followed as far as possible.

The steepness of the surface and the stony character of both the soil and subsoil combine to render this type of little agricultural value. It is almost entirely covered by a sparse, second-growth forest of jack and scrub oak and black aspen, yielding timber of little value. The open character of the growth permits the formation of a fair turf of blue grass, which affords some pasture, and where the timber is removed and the slope is not very steep an excellent natural growth of that grass may be secured. No effort has been made to grow crops other than grass on this type of soil. It would seem that it might be utilized to some extent for the production of grapes and valuable timber trees. The surface should not be left exposed to erosion, and the maintenance of a timber covering is one of the best means for its utilization.

The following table gives the mechanical analyses of soil and subsoil of this type:

Mechanical analyses of Clarksville stony loam.

[Fine earth.]

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6694	3 miles SW. of Dubuque.	Black silty loam, 0 to 14 inches.	1.67	0.10	0.72	1.00	6.54	13.26	72.54	5.74
6692	5 miles SW. of Dubuque.	Black silty loam, 0 to 14 inches.	2.93	.36	.86	.42	1.20	3.88	74.14	18.96
6695	Subsoil of 6694.....	Light-brown clayey silt, 14 to 36 inches.	.95	.70	2.00	3.14	25.08	19.12	42.34	7.22
6693	Subsoil of 6692.....	Brownish-yellow silty clay, 14 to 36 inches.	1.13	1.62	1.24	.66	6.70	10.16	57.02	22.22

MIAMI SANDY LOAM.

The Miami sandy loam is found entirely in the western third of the sheet, where it occurs in three elongated areas with a general southeast direction. The first extends from Farley to Epworth, the second reaches from northern Whitewater Township to the vicinity of Fillmore, and the third stretches from Cascade to a point about 3 miles south of Garry Owen. The material is probably of Iowa glacial origin and of moraınal character. The surface is rolling and the most southern area follows the course of the North Fork Maquoketa River and one of its tributaries. Near Fillmore it crosses the high bluffs along John Creek. In general the outlines of the surface are rounded,

and in the two lower areas there is a semblance of the billowy forms due to wind action.

The soil consists of a gray to dark-brown sandy and silty loam 6 to 12 inches in depth, containing occasional angular pebbles. This rests upon a subsoil of brownish to yellow loamy sand at a depth of 20 or 30 inches. The included sand is of medium and fine grade and varies in quantity in different parts of the area. The soil and subsoil are heaviest in the area around Epworth, while in the other two areas knolls of light, loose sand are frequent. The type is particularly variable within itself, the loose, shifting knolls and ridges alternating with the heavier loam areas. The basal material ranges from a light sand to almost a clay, with that indefiniteness which characterizes soils of morainic origin.

The Miami sandy loam is devoted to the production of grain and grass, the yields of which are fair. The natural fertility is sufficient to produce good crops, but the soil is much affected by drought, and hence the returns are largely determined by the rainfall. As compared with the silt loam the crop yields are lower. More careful management for the conservation of soil moisture and fertility are necessary on this type. With such careful treatment truck crops and fruits may be added to the list of crops at present grown.

The following table contains mechanical analyses of typical samples of this soil and subsoil:

Mechanical analyses of Miami sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6688	¼ mile E. of Farley..	Dark sandy loam, 0 to 12 inches.	2.11	1.02	8.24	19.66	31.80	9.56	18.18	10.98
6690	Center of section 25, Whitewater Township.	.....do.....	1 67	.74	9.20	30.08	28.50	2.48	16.74	12.30
6691	Subsoil of 6690.....	Brown sand, 12 to 36 inches	52	1.16	9.78	33.00	35.38	1.40	11.00	8.22
6689	Subsoil of 6688.....	Brown clayey sand, 12 to 36 inches.	.74	.40	6.38	19.06	33.30	11.26	18.94	9.80

MIAMI FINE SAND.

The fragments of terraces along the borders in the inner gorge of the Mississippi River give rise to a type of soil that is a few grades finer than the Miami sandy loam. The soil to a depth of 12 inches is a dark sandy loam, the sand consisting largely of the finer grades.

This rests upon a slightly loamy brownish to yellow sand that extends to a depth of several feet. The phase above the bluff is lighter in texture and color, and of a more uniform fineness, and is free from the occasional pebbles that occur at the lower levels. In all areas there is a tendency toward loose, shifting sand, knolls of which are frequently found.

The main area is below the bluff southeast of Dubuque and on the east side of the river, where the surface slopes from an elevation of 640 feet to the level of the river channel at the water's edge. This area extends for 5 miles along the river. On the west side of the river is a similar body of soil, upon part of which is situated the town of Dubuque. Farther south the only areas of the type at these levels is a narrow ribbon of sand at the foot of the cliff. In addition to the areas already mentioned there occurs a long, narrow strip of a modified phase of this soil on the bluff on the Illinois side of the river. In this situation the soil is derived by wind transportation from the terrace sands. It rests on the loess formation, and has a rolling, billowy, dunelike surface. The surface of the type at lower levels is less rolling, but yet is gently undulating.

The greater part of this soil is under cultivation, and fair crops of grain and grass are grown. Its light and open character renders it especially susceptible to the effects of drought, and careful management is necessary to maintain the naturally high fertility of the terrace areas. Besides the grain crops it may also be expected to give good yields of all the truck crops suited to the climate.

The following table shows the texture of typical samples of this type:

Mechanical analyses of Miami fine sand.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6696	3 miles SE. of Dubuque.	Brown fine sandy loam, 0 to 12 inches.	1.30	0.70	4.94	5.64	45.60	29.54	9.24	4.44
6698	3 miles SE. of Dubuque.	Sandy loam, 0 to 18 inches.	1.32	.58	20.78	27.50	28.42	6.50	8.92	7.24
6697	Subsoil of 6696....	Fine yellow sand, 12 to 36 inches.	.21	.24	3.74	4.88	51.96	31.20	4.02	3.92
6699	Subsoil of 6698....	Brown, slightly heavy sand, 18 to 36 inches.	.64	.32	17.42	25.96	35.58	10.32	5.86	4.50

LINTONIA LOAM.

All the streams except the Mississippi River are fringed by a ribbon of low, flat land of varying width. The soil of these areas is col-

luvial, derived from the wash of the slopes at higher elevations. It occupies the position in which is generally found wet meadow land, but on the whole differs from the latter in being quite level, comparatively well drained, and much more uniform in texture. Through this bottom land the main channel of the stream winds between almost vertical walls. The areas of this soil are occasionally overflowed, but rapidly recover from the effect of the flood and where of sufficient extent are cultivated.

To a depth of from 3 to 6 feet the Lintonia loam consists of a dark to black silt loam, interstratified in some parts with thin layers of fine sand. Through the areas of sandy loam the soil is of a more sandy character. The percentage of organic matter is always high. In the eastern part of the area surveyed, where the stream valleys have a steep slope riverward and flow between rocky walls, the soil material rests upon a mass of rock fragments. Farther west the basal material is a silty wash, sometimes of a yellowish color.

The limited extent of this type and the fact that it is often bordered by the stony loam have led to its general use as pasture land only. It is very fertile, yielding excellent crops of all the grains and grasses and capable of producing a variety of truck crops.

The largest areas are found in the western part of the area surveyed, usually at the head of streams, south of Epworth and between Bernard and Fillmore. These were originally wet, mucky quagmires that are just now becoming sufficiently dry to permit cultivation.

The following table shows the texture of this soil:

Mechanical analyses of Lintonia loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
6701	3 miles SW. of Dubuque.	Black silt and fine sandy loam, 0 to 36 inches.	4.83	0.28	1.58	3.12	22.28	12.62	50.82	8.74
6700	3 miles SW. of Lamotte.	Black silty loam, 0 to 36 inches.	3.59	Tr.	.54	.32	1.22	6.76	79.34	11.80

MEADOW.

The extent of meadow land in the area is small and is confined mainly to the lower portion of the inner gorge of the Mississippi River, where occur a number of low islands cut off from the shore by side channels and bayous. The nearness of standing water to the surface, added to frequent overflows in times of high water, renders

this type of little present agricultural value. The material is a variable mixture of sand and silty mud that has been dropped by the water as its current was checked, and until the process of soil formation has gone far enough to raise these areas permanently above the flood level they will continue to be, as they now are, useless lands as far as agriculture is concerned.

AGRICULTURAL CONDITIONS.

The generally well kept farms, commodious farm buildings, and modern machinery seen throughout the area indicate a fairly prosperous condition of the agricultural classes. A large proportion of the farmers are of foreign parentage, and their thrift and industry have built up a profitable system of agricultural practices. The farms as a rule have a large acreage, ranging from 150 to 600 acres on the more level uplands and from 100 to 400 acres in the vicinity of Dubuque. There are smaller holdings, but the number of such is limited. The idea of extensive farm operations, which seems to dominate the farmers, has led to the use of many-horse teams and wide-cutting implements and to the sacrifice of thoroughness and efficiency, sometimes, for rapidity.

The present value of the farms ranges from $40 to $80 per acre, depending on the proportion of uncultivable land and the distance from market and the direct means of transportation. Land values are at present increasing. The farms are tilled largely by the owners, but some renting is also practiced, both for a share in the products and for a money rent. The latter method is becoming more general. Farm labor is done mainly by the farmer and his family, hired labor being scarce and commanding wages ranging from $20 to $30 per month with board.

The general system of farm practice is based upon the production of grains and grass, which are almost entirely fed to live stock, and thus marketed in the form of meat, wool, and dairy products. The foremost crop in acreage and yield is corn. This is the mainstay of the farmer and is never a complete failure. It is said that during the season of 1901 one-half to two-thirds of a full crop was produced without an effective rain during the growing season. The yield of corn varies somewhat in different parts and upon the different soils of the area surveyed. The dark loams on the prairie produce from 35 to 80 bushels and the remaining area gives from 25 to 65 bushels per acre. Besides corn a considerable quantity of oats and some rye and barley are produced. The hay crop is a large one, consisting of timothy and clover, mixed and separate. During the last three years difficulty in securing stands of clover, together with winter injury of the young plants, has greatly reduced the acreage of that legume, and a substitute that will withstand the rigor of the climate is needed to balance

the dairy and beef rations and keep up the fertility of the land. It would seem that alfalfa, a legume comparing favorably with clover in all particulars, might be introduced. The yields of hay vary between 1 and 2 tons per acre. For pasture, blue grass is commonly used. This is well adapted to all the silty soils, and occupies the soil naturally within from three to six years, forming a dense, thrifty sod. The hay meadows also furnish a limited amount of pasture.

Throughout the county there is a noticeable absence of orchards and of fruits of all kinds. At long intervals one may see a few old apple trees that have almost passed beyond bearing, but of other fruits there are none. The general farm operations claim all the attention of the agriculturist and the care that is necessary to enable fruit to withstand the severe winters and numerous insect enemies is not forthcoming. In the southern part of the area, at a number of points around Cascade, Bernard, Zwingle, and St. Donatus, small plantings of apples have recently been made and the trees appear thrifty.

The river bluffs are among the best fruit lands in the State of Iowa, the only difficulty being an occasional winter of unusual severity which kills all weak trees. Such a one was the winter of 1898–99, when not only fruit but forest trees were killed or permanently injured. In view of this only hardy varieties of fruit should be planted. It would seem that at least enough fruit should be produced to supply the home demand, and there are possibilities for development of the industry on commercial lines.

The live stock on the farms consists mainly of cattle and hogs. The cattle raised are both for beef and for dairy purposes. The milk is largely manufactured into butter in central factories, of which there are nine located in the area. The skim milk is returned to the farm and used for feeding calves and pigs. There is little distinction between the two types of animals used for dairy and for beef purposes, as they are of mixed breeds, with a possible predominance of Shorthorn blood. The hogs also are of mixed breeds, though there is a general predominance of the Poland-China characteristics. It is generally conceded that the different breeds of live stock have been so developed that they are adapted to particular uses; that an animal of the beef breeds is not a profitable one for the dairyman, and that in every instance most satisfactory returns are derived from animals whose pedigrees show that they have been kept close to the established strains. In this particular the horses in use in the area show an adaptation of the animal to the work, for the farm horses are large, muscular, and well built for draft purposes, but in case of cattle and swine there is opportunity for great improvement.

The roads are hilly and irregular. The topography of the country is such that land lines could not be followed, and even with the present system the frequent steep grades are a serious impediment to hauling

even moderate-sized loads. Besides being steep the roads are almost entirely composed of earth, using the material nearest at hand, and hence they are largely clayey and easily affected by rains or frost. Every hill is a mass of limestone, one of the best road materials to be had, and with a crusher in each township great improvement in the roads might be cheaply brought about.

Railroad transportation facilities are better. There are four lines of railroads that touch or cross the area. The Illinois Central and the Chicago and Northwestern traverse the northern part of the area, the Chicago, Milwaukee and St. Paul follows the river south, from which a narrow-gauge branch reaches from Bellevue to Cascade, and the Chicago, Burlington and Northern runs into East Dubuque. There is also a line of boats on the Mississippi River. With all these means of connection with the centers of Eastern and foreign trade the facilities for marketing the produce of the area are remarkably good. The live stock produced is within seven hours' run of the greatest slaughtering houses of the world, and the duplicate lines insure fair rates for these as well as for grain shipments. The butter manufactured in the creameries is shipped to Chicago and New York.

The chief opportunities for improvement are along the lines of industry already established and lie in the introduction of a better breed of live stock, in the adoption of a less extensive system of cropping, and in the improvement of the soil by a larger use of leguminous plants in the rotation. In the past no commercial fertilizers have been used and none seem very necessary. Stable manure is saved and returned to the land. There is some loss in the handling of this that might with a small degree of care be prevented. The agricultural conditions compare favorably with those in other areas that have been surveyed.

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SOIL MAP

IOWA - ILLINOIS
DUBUQUE SHEET

91°00'
50'
40'
90°30'
42°30'
42°15'
20'
SOIL PROFILE
(3 feet deep)
Clarksville stony loam
Lintonia loam
Miami sandy loam
Miami fine sand
Miami silt loam
Meadow
LEGEND
Csl
Clarksville stony loam
Li
Lintonia loam
Ms
Miami sandy loam
Mfs
Miami fine sand
Msl
Miami silt loam
M
Meadow
IOWA
CENTER
DUBUQUE
JULIEN
DUNLEITH
MENOMINEE
TAYLOR
VERNON
TABLE MOUND
MOSALEM
WHITEWATER
PRAIRIE CREEK
WASHINGTON
PRAIRIE SPRING
BUTLER
RICHLAND
Dubuque
East Dubuque
Menominee
Julien
Centralia
Rockdale
Key West
Epworth
Peosta
Ballyclough
Massey
Kings
St. Donatus
Bennettville
Buncombe
Melleray
Fillmore
Bernard
Cascade
Washington Mills
Zwingle
Garry Owen
Bellevue
Lamotte
MISSISSIPPI RIVER
DUBUQUE CO.
JACKSON CO.
JONES CO.

Soils Surveyed by
Elmer O Fippin
1902

BASE MAP ENLARGED AND REDRAWN
FROM U.S. GEOLOGICAL SURVEY SHEET

Scale 1 inch = 1 mile

Contour Interval 20 feet

Field Operations
Bureau of Soils
1902